THE REVERSING RAPIDS AT SAINT JOHN, NEW BRUNSWICK

By F. Keith Dalton

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For many decades, the tidal phenomena and famous tourist attraction, near the mouth of the St. John River, have been known as "The Reversing Falls." There is not a waterfall, however, but a powerful tumbling rapids on the normal downstream flow of the river followed by a very strong upstream current when the rising tides take control and reverse the direction of movement of the water.

In an earlier issue of the Journal, (vol. 45, p. 225, 1951) under the title: "Fundy's Prodigious Tides and Petitcodiac's Tidal Bore", the writer explained the origin and described the nature and behaviour of the phenomenally high tides in the Bay of Fundy and the Minas Basin, and their effects on the shores and in the tributary rivers. The tides in the Basin are the highest in the world, 53½ feet, with nearly as high tides at the upper end of the Bay, so the conditions produced in the rivers are extreme.

In brief, the tides which affect the Bay of Fundy, and the rivers which discharge into it, commence in the southern Indian Ocean, west of Australia, and move westward increasing in magnitude as they travel until, passing around the Cape of Good Hope at the south end of Africa, they turn northward and proceed up the Atlantic Ocean. They reach their high levels on New Brunswick and Nova Scotia shores about twelve hours after the moon has crossed the local meridians. In the Bay of Fundy the tides are anomalistic—varying chiefly with the distance of the moon rather than with its phases and declination.

The Bay opens to the south so receives the tides directly as they rush northward in the ocean. As there is a resonant condition in water movement along this part of the North American shore, with nodes near Nantucket Island, very much higher tides are built up at the northern resonant loops which occur in this Bay. Moreover, the Bay becomes narrower and shallower toward its upper end causing the waters to build up to most unusual heights in the upper reaches and the tides rush on, still increasing, into adjoining Chignecto Bay and the Minas Basin where they attain maximum heights.

The St. John River, about 450 miles in length—the longest river on the North Atlantic seaboard with the exception of the St. Lawrence—flows into the Bay of Fundy at the city of Saint John, New Brunswick. At this

point, Fundy's tides rise to a height of 28½ feet and reverse the flow in this river for a considerable distance upstream from its mouth creating fresh-water tides farther up by pushing back the normal river waters. While every river or brook that flows into the Bay of Fundy, the Minas Basin or associated bays, suffers reversal of flow when tides rise, any of these streams which happens normally to have rapids near its mouth will also have a so-called "reversing rapids". The chief claim to fame then of the phenomena at Saint John is based upon the enormous amount of river water involved and the great strength shown by the rising tides in overcoming the flow. It is a very spectacular sight and well worth a visit to observe.

The Rapids. During the normal downstream flow of the St. John River, during a long period under low-tide conditions, there is about one half mile of vigorous turbulent Rapids over a rocky bed, through a narrow cliff-walled gorge and under the railway and highway bridges into the harbour. (See figures 1 and 2.)

The overall possible difference in level between the brink and tail of these Rapids is about 14½ feet. As the rise of Fundy's tides is about twice this amount, the tide waters can and do completely overcome the Rapids twice each day.

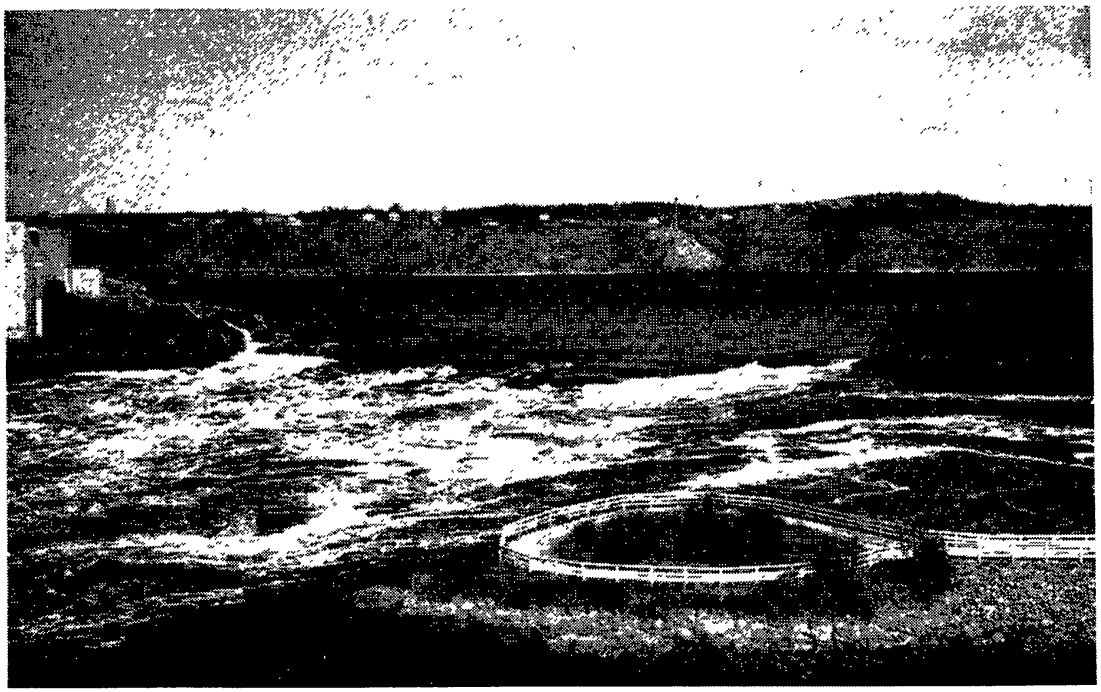

FIG. 1—The brink of the Rapids and turbulent downstream flow of river waters at low tide. Several observation areas are provided for visitors. (Courtesy of the Saint John Municipal Tourist Office.)

FIG. 2—The discharge of the Rapids at low tide—under the railway and highway bridges and through the gorge into the harbour. (Courtesy of the Saint John Municipal Tourist Office.)

While tide levels rise, the tide waters creep up the Rapids, with normal river flow continuing downstream and over the top of the incoming tides. There is no really clear demarcation while the tides overcome the Rapids —until about the time that the rising levels reach the brink. In the same way, while the tides are ebbing, there is no definite line or sudden change where the receding tide waters are leaving the Rapids.

Slack Waters. In tidal streams, slack water occurs when the flow stops in one direction and is about to start in the opposite direction. There are two such cessations of flow in each complete cycle of events but these very rarely occur at the same times as high and low tides. There is usually some delay.

When the rising tides, creeping up the Rapids, reach the brink, the cessation of flow is known as "Low Slack Water." This occurs about 3 hours 50 minutes after low tide in the harbour.

The flow reversal above the Rapids, over the brink, now begins—and this upstream movement lasts for about 4 hours 40 minutes. By that time, tides are ebbing in the harbour and in this part of Fundy so again, and this time at highest level, there is the second cessation of movement and the flow is about to start in the downstream normal direction (see figure

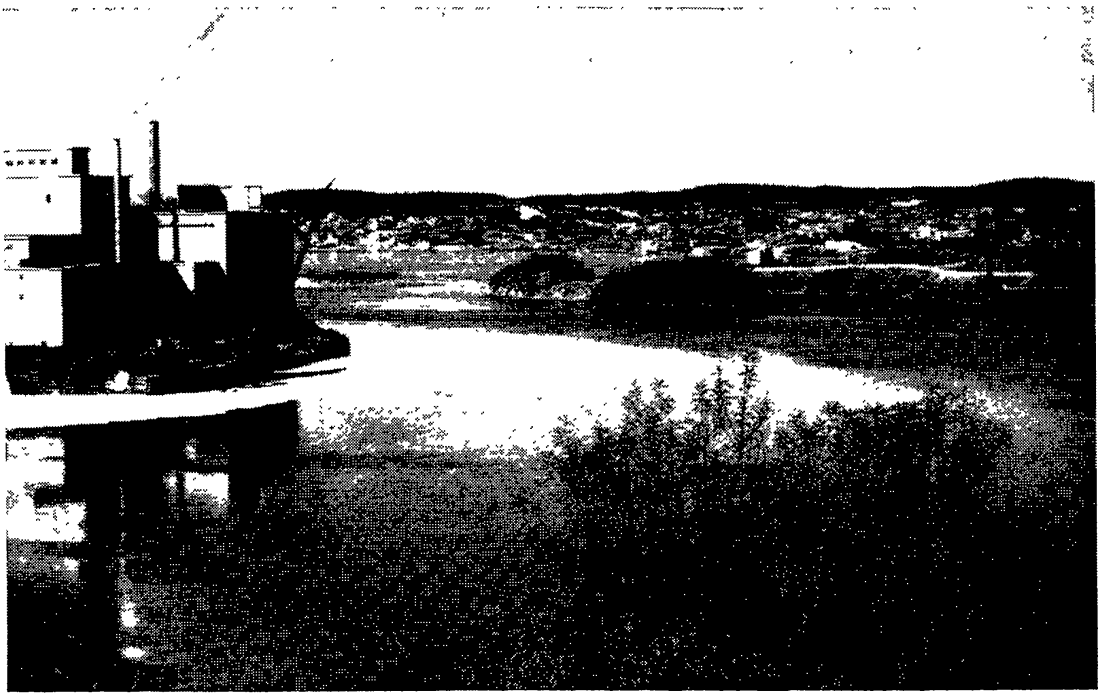

FIG. 3—Upstream end of the Rapids area at high slack water when the tides have stopped the river flow—and navigation over this area is possible. The white area of the water is quietly floating foam. (Courtesy of the Saint John Municipal Tourist Office.)

3). This stage is known as "High Slack Water" and occurs about 2 hours 25 minutes after high tide in the harbour.

The waters now have flooded the Rapids area so only eddies and ripples in the stream are to be seen. Under these high-water conditions, navigation past the Rapids by small craft is possible and safe for about 45 minutes, and is quite customary (see figure 4). These boats take advantage of the upstream flow, just before high slack, to move in that direction but hasten back down stream with the outgoing tide before the water over the brink of the Rapids becomes too shallow for safe passage. Those who navigate this area must keep close check on the times at which the various phases of these phenomena occur each day—and there is a complete cycle of events every 12½ hours but one hour later on each successive day. To ignore the tidal movements and the tide tables could easily result in a shipwreck.

For a half hour or more after high slack water, there is downstream flow but no evidence yet of rapids for the water level over the brink is still too high, the water too deep. Then the Rapids appear and increase gradually in length and more vigorous flow. This impressive sight lasts until the tides creep up over the Rapids again to reach the brink at the next low slack water, a period of about six hours.

FIG. 4—Downstream end of the Rapids area at high slack water with two small vessels, a tug and a tanker, moving upstream through the gorge and under the bridges—viewed from an observation area beside the Tourist Centre. (Courtesy of the Saint John Municipal Tourist Office.)

Varying Conditions. The lengths of the periods of upstream flow, from low slack to high slack, and of evident downstream rapids, vary with the amount of rise of the tides in the Bay of Fundy—from 21 feet, minimum, to 28½ feet, maximum. The amount of water flowing over the Rapids, however, varies considerably with river flood and dry season conditions as well as with the amount of tide water forced up the river. The greatest discharge over the brink of the Rapids, as far as tidal conditions alone are concerned, occurs just after the brink appears, nearly an hour after high slack water. With the large amount of outgoing water, the river level now is dropping so, with lowering head of water, the discharge over the Rapids gradually decreases until the next low slack occurs. Precipitation, of course, will affect the river flow in any season.

The matter of power development at these Rapids has, undoubtedly, been given serious thought but the periodic reversals of flow of water and particularly the slack phases, when there is no available operating head, present a difficult problem. Nevertheless, the tidal waters of Passamaquoddy Bay, along the Fundy shore and about 50 miles west of the city of Saint John, are now being carefully considered for development and, if the problem can be solved satisfactorily there, the Reversing

Rapids may be harnessed later. However, generating stations that depend upon tidal movements can not be operated on isolated power systems; they must be connected to other stations which provide steady power. The Province of New Brunswick already has a suitable power system which could absorb the periodic output from tidal generating stations, and make full use of it, so success in such development may be realized there in the near future.

Observing the Rapids at Saint John. The Reversing Rapids are astronomical phenomena of decided interest to both professional and amateur astronomers for they demonstrate the gravitational effect of the sun and moon on the oceans of our earth, and present the results at very close range. These Rapids also form a very fine tourist attraction for the city of Saint John and are conveniently placed for observation.

Unlike the tidal bore at Moncton, about 90 miles away to the east, the Reversing Rapids are not just a short-time entertainment, lasting only a few minutes twice a day. The whole cycle of events at the Rapids spreads over 12½ hours, and these cycles occur about an hour later on each successive day. There are nearly two complete cycles every day.

Probably the best time for the observer to arrive at the Rapids is about halfway between low slack and the next high slack water. He then will see first the reversed upstream flow of water gradually decreasing over the next two hours, until standstill at highest level. He can now watch the flow start downstream again and become faster. In about an hour, the brink of the Rapids will begin to form and the waters increase in turbulence. The development of the Rapids is most interesting but, while the tail edge of the retreating tide is not well defined, one is aware of the gradual increasing and lengthening of the turbulent area until the full flow of the Rapids is exposed. This will require about three hours following the appearance of the brink. The astronomer or tourist, therefore, should count upon spending about six hours at the Rapids area in order to see all of the chief phases and thus get the best impression of the phenomena. He may, of course, slip away for short periods to visit the central part of the city, only a mile distant, provided he choose carefully just when to be absent so as not to miss the important events at the Rapids.

To aid the visitor and observer, Tide Tables for the Rapids are published every summer by the Municipal Tourist Development Office at Saint John and are distributed to all who desire them—either sent by mail or handed to the tourist when he arrives in the city. There are several observation areas provided and well placed for good views of

the Rapids. As a further aid to ensure that the visitor shall have a continuous view of the phenomena, the Rapids are illuminated every night. This is very striking for there is so much foam moving with the water that the eddies and turbulence are clearly outlined by the illumination.

In observing phenomena such as the Reversing Rapids at Saint John, one is likely to find a few surprises for, although all aspects of the various phases have been calculated closely and predicted for him in both time of occurrence and rise of the tides, he often finds some feature which he has not just expected. Such surprises add greatly to the interest of the visit.

While the Tide Tables give the times of high and low tides in the harbour, and of high and low slack waters at the brink of the Rapids, they do not attempt to explain the strange feeling of nervous tension that one experiences as he watches the strong upstream current during reversal of river flow—as though it must lead to some dire consequences—and then realizes the sudden release of tension as the flow stops, starts downstream to become normal again.

The Reversing Rapids are well worth a visit and the spending of six or seven hours to watch, whether the observer be interested in astronomy or be an inquisitive tourist.

THE ORBIT OF THE SPECTROSCOPIC BINARY H.D. 174369

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The star H.D. 174369, α (1900) $18^h\ 45.1^m$, δ (1900) $+ 24°56'$, vis. mag. 6.56, spectral type A2n, was announced to be a spectroscopic binary in 1945 at the David Dunlap Observatory (Young 1945). In 1955 there were 29 plates available for a determination of the orbit. Additional information was required to resolve an uncertainty in the period. In 1957 and 1958 eleven more plates were obtained for this purpose. All plates were taken with the 25-inch camera of the one-prism spectrograph at the Cassegrain focus of the 74-inch reflector at the David Dunlap Observatory, giving a dispersion of about 33 A./mm. at Hγ. The lines used for the radial velocity determination were selected from among the following: 3933.664, 4045.739, 4063.539, 4071.687, 4077.644, 4143,682, 4226.911, 4233.275, 4250.481, 4271.548, 4282.621, 4307.892, 4315.786, 4325.674, 4340.466, 4351.839, 4443.578, 4468.643, 4481.310, 4549.550. The diffuse nature of the lines made it impossible to measure all of those listed for each spectrum. However $\lambda\lambda$ 4340 and 4481 were measured on

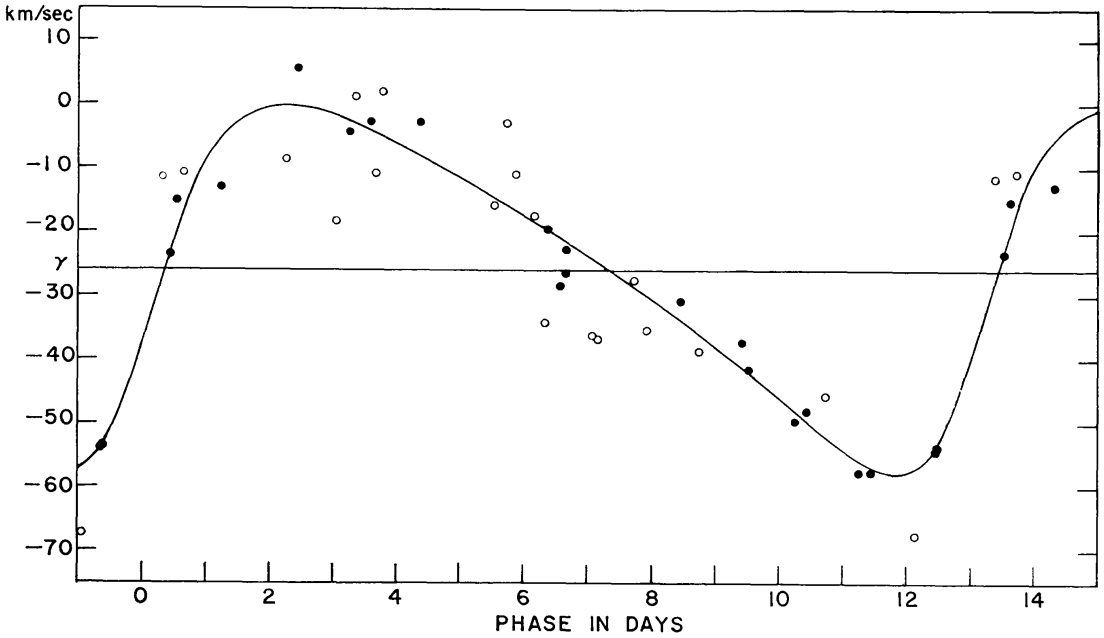

Fig. 1—Radial-velocity curve for H.D. 174369.